TESTING PLAN

FOR THE LAND-BASED TYPE APPROVAL TESTING OF BalClor™ BWMS OF SUNRUI CORROSION AND FOULING CONTROL COMPANY

Prepared by: Wang Haitao Date: 2009.8.19

Checked by: Liu Guangzhou Date: 2009.8.19

Approved by: Fu Hongtian Date: 2009.8.19

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1. Project Description

Sunrui Corrosion and Fouling Control Company (Sunrui CFCC) has developed a ballast water management system (BalClor™ BWMS, Previously the name of "Sunrui BWMS" was used.) to treat ballast water on board through pre-filtration followed by disinfection with Active Substances (AS) produced by an electrolytic process during ballasting, and neutralization at de-ballasting.

When ballasting, the ballast water is firstly filtrated by an automatic self-cleaning filter with 50μm screen, to remove large plankton and solid particles. Then, at disinfection step, a side stream of seawater flows through an electrolytic unit to produce sodium hypochlorite solution, which is injected back into the main ballast pipe to the ballast tanks to kill the residual planktons, pathogens, larva or spores. Experiments results have showed that the ballast water treated by filtration and disinfection steps fulfills the Regulation D-2 of IMO BWM Convention, when the Total Residual Oxidant (TRO) level for disinfection in ballast water ranges from 7.5 to 9.5mg/L.

When de-ballasting, sodium thiosulfate solution is added into the treated ballast water to neutralize the residual TRO. The neutralization step will be always employed prior to discharge to ensure no unacceptable risk to the receiving environment. The dose of the neutralizer depends on the TRO concentration in the ballast water for discharge and is controlled automatically.

Sunrui CFCC started the development of BWMS in 2006. A prototype BWMS with treatment capacity of 250m^3/h was designed and manufactured by the end of 2007.

In June 2008, a land-based testing facility with flow rate of 250m^3/h was established in Qingdao in accordance with the IMO Guidelines (G8 Guidelines for Approval of Ballast Water Management Systems). The performance of the BalClor™ BWMS has been tested since August 2008, and based on the testing and research work, the basic operational parameters of the BalClor™ BWMS have been defined. Meanwhile, the application for Basic Approval was submitted to IMO in August 2009.

According to the IMO G8 and G9, the full scale testing of the BWMS shall be conducted at land-based testing facility for Type Approval and for Final Approval. This testing plan covers the general planning of the full scale land-based type approval testing, including the toxicity testing requested for application of Final Approval.

2. Objectives

The objectives of the full scale land-based Type-approval tests are:

- to test the performance of discharge waters treated by BalClor™ BWMS in accordance with the IMO Guidelines (G8);
- to conduct the discharge toxicity tests, as part of land-based type approval process, on samples drawn from the land-based test set-up in accordance with the Procedures (G9);
- to prepare the application dossier for Final Approval using the results and data from the land-based tests.

3. Project Organization and Personnel Responsibilities

3.1 Presentation of Project Organization

3.1.1 Presentation of Sunrui Corrosion and Fouling Control Company

Sunrui Corrosion and Fouling Control Company was established in 2003 (Qingdao branch of Luoyang Ship Material Research Institute from 1982 to 2003), and is a high-tech company in research and development, design and manufacture of corrosion and fouling control products. At present, there are 205 staff members in the company, including more than 80 technical personnel. The headquarters of the company is located in Qingdao, with two branches located in Shanghai and Luoyang, Henan Province respectively. The company obtained CERTIFICATE OF CONFORMITY OF QUALITY MANAGEMENT SYSTEM CERTIFICATION (GB/T19001-2000 standard (idt ISO9001:2000)), CERTIFICATE OF CONFORMITY OF ENVIRONMENTAL MANAGEMENT SYSTEM CERTIFICATION(GB/T24001-2004 standard (idt ISO14001:2004)), and CERTIFICATE OF CONFORMITY OF OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM CERTIFICATION (GB/T28001-2001 standard).

With more than 40 years of research achievements, the company by now has a first-grade technical team in corrosion and fouling control field. The company developed more than 20 standards on corrosion control and electrolytic antifouling for state, ministry, and military

under authorization. The products of cathodic protection, electrochlorination and ship sewage treatment have been widely applied in ships, harbor installations, marine projects, underground pipelines, power plants, chemical plants, municipal facilities etc., and exported to more than 10 countries and regions such as U.S., Japan, Netherlands, Indonesia, Singapore, Pakistan, Sri Lanka, Iran, Sudan, Hong Kong, and so on.

Figure 1 Headquarters of SunRui Corrosion and Fouling Control Company in Qingdao

3.1.2 Presentation of Pony Testing International Group

PONY TEST (Abbreviation for PONY Testing International Group) is reformed from the national scientific research institution. With our strong scientific research background, PONY TEST grows continuously with amazing speed. As a leading and comprehensive testing organization, we have the qualification of CNAS and CMA, which obtains mutual recognized agreement in 58 countries and regions, including USA, UK, Germany, etc. PONY TEST provides reports which have obtained international approval and credit. Up to now, with over 1000 employees, we have established 6 large laboratories in Beijing, Shanghai, Shenzhen, Qingdao, Tianjin and Ningbo in China, 8 subsidiaries and 29 branches worldwide, across UK, HK etc., which builds an international testing network. In 2007 and 2008, PONY TEST were honored of "Deloitte Technology Fast 50 China" and "Deloitte Technology Fast 500 Asia Pacific" continuously.

Fields of RoHS/PoHS/PAHs and Halogen-free test of the Electric and Electronic Equipment

As the only Chinese representative unit of IEC TC111 WG 3 (International Electrician

Committee), PONY TEST has been responsible for drafting European Union RoHS standard. Being the earliest global lab in RoHS testing field, PONY TEST also take the part in drafting Chinese RoHS standard and helping National Departments to hold RoHS instruction meeting. In 2002, PONY TEST was accredited by Motorola and became its exclusive material analysis laboratory in Asia. In 2005, PONY TEST became one of the first accredited RoHS test organizations by China Quality Certification Center, and was authorized by American UL and Panasonic group as their RoHS testing lab. In 2007, PONY TEST was honored as the designated RoHS testing facility by national Institution of Industry and Commerce Administration. Taking the national scientific research project "Green Electrical and Electronic Product Quality Assessment System", PONY TEST also obtained the innovation fund certification of National Science and Technology Ministry of China, following by becoming the testing organization of Chinese Mechanical and electrical products Import and export Association in 2008.

With our due authoritative knowledge in electric examination, PONY TEST provides testing service in RoHS, PoHS, tetrabromobisphenol A, PAHs, Halogen, Motorola W18 testing and other kinds of test for virulent deleterious substance. As assigned RoHS testing organization of industry and commerce bureau, PONY TEST has been responsible to spot-checking the quality of electronic products in circulation field.

Fields of Medicine and Food Test

PONY TEST is designated by Ministry of Agriculture as the inspection organization for green food, non-nuisance agricultural products, environment of non-nuisance agricultural products and quality identification of agricultural products. Authorized by Certification and Accreditation Administration of PRC as one of the firstly designated inspection organizations for organic food;

PONY TEST are authorized by the Ministry of Commerce of PRC as the designated inspection organization for green Chinese traditional medicine mark; PONY TEST assist Industry and Commerce Administration to take the random inspection of food quality in circulation field and undertake the state council flour food & China astronaut center food nutrition and safety testing task in the long term as well. PONY TEST has also the function as the Makro supermarket food quality test designated lab and the globally highest level cooperative lab with P&G group. In 2007 PONY- P&G special lab was formally established and started to work; plus, PONY TEST is the only designated lab of Hershey's, the biggest player in American Chocolate Industry.

PONY TEST provides the testing service of melamine, nutrient, active ingredient, heavy

metal, pesticide residue and veterinary medicine remaining in food. Serving as the function unit for the testing of Ministry of Agriculture, National Department of commercial affairs organic foods, Green traditional Chinese medicine and the related scientific research topics in food security, traditional Chinese medicine deleterious substance research and so on. PONY TEST coordinated with industry and commerce administration department to spot-check the safety of food in market.

Fields of Environment and Water quality test

As the national designated environmental standard sample formulating laboratory, PONY TEST is authorized as one of environmental monitoring organizations by Beijing Municipal Construction Committee and China Environmental protection Industry Association. By our advanced testing technology as well as good connection with regional environmental protection bureau, PONY TEST provides the testing for water, soil, atmosphere, noise and service for environmental effect appraisal, environment testing training, construction & decoration finishing material testing, indoor environment testing, occupational health testing, acceptance of work, gas station and fuel depot oil gas recycling testing, 14000 environmental management authentication testing and so on. In the period of the 29th Beijing Olympic Games, PONY TEST provided the environment and water testing service for Olympics tennis center and the Olympics aquatic park.

Fields of Toys/Textiles/Cosmetics/Automotive test

PONY consumable goods testing lab provides comprehensive service, involving in chemicals, textiles, toys, stationeries, ceramics and vessels, etc. PONY TEST has been accepted as an accredited lab by Consumer Product Safety Commission (CPSC). To serve for the preparation of 29th Beijing Olympic Games, PONY TEST worked with Industrial and Commercial Administrative Bureau in sample inspection for hotel disposable products as well as child clothing, toys, microwave food containers, daily cosmetic products in supermarkets, stationeries and so on .

Fields of cargo transportation condition identification/ lithium battery test (UN38.3)

As the cargo transportation condition identification institution approved by Civil Aviation Administration of China, PONY TEST has successfully obtained approvals from many airline. Set up offices at Shenzhen Bao'an Airport and Shanghai Pudong Airport, PONY TEST provides more convenient and quick cargo transportation condition identification, lithium battery UN38.3 testing and magnetic testing for transportation enterprises.

Fields of REACH, GHS and MSDS

REACH, namely the Registration, Evaluation, Authorization and Restriction of Chemicals, as the regulation of European Union, preventively manages all chemicals on market. After REACH is formally released, GHS (Globally Harmonized System of classification and labeling of chemical) is the system for addressing classification and labeling of chemicals. By the right advantage and experience in the electronic examination field, PONY TEST provides REACH training, testing and related solution for our clients. As a famous MSDS certification organization, PONY has tremendous of MSDS chemicals data, and has also drafted many formats MSDS, which conform to many countries standard in various languages. MSDS report issued by PONY TEST will facilitate China companies to export their products smoothly.

3.1.3 Presentation of the First Institute of Oceanography, SOA

The First Institute of Oceanography, SOA is a comprehensive oceanographic research institute engaged in applied and basic researches, high technology development and serving the public. The institute aims at promoting the marine science and technology progress and serving the marine management, marine safety and marine economy development and is an important marine science research entity in the national science and technology innovation system. Her main research fields include the distributions and variabilities of natural environmental elements in Chinese seas, their adjacent oceans and polar sea areas, the marine resources and environmental geology, the generating mechanism and prediction method of marine disasters, the variabilities of marine ecology environment, the remote sensing oceanography and marine information system, the assessment, protection and regulation of marine environment, the marine high technology development and marine comprehensive management sciences.

In the past 45 years from her establishment, the institute has been developing into a marine science research institution well-known at home and abroad. The institute now has about 320 senior researchers and is equipped with internationally advanced survey equipments, experimental installations and auxiliary facilities for scientific research. The accomplished national major science and technology thematic projects, national key basic research projects, national tackling key science and technology problem projects, national major and key foundation projects, marine engineering prospecting and development projects and the acquired scientific achievements have demonstrated the international level of her prime work. As an international cooperation window of SOA, the institute has taken charge of many large-scale international cooperation projects, including Sino-US joint study on air-sea

interaction in the western tropical Pacific, China-Japan joint study on the Kuroshio, China-France joint study on the sediment transport from the Changjiang River estuary to the Okinawa Trough, China-Korea joint study on ocean circulation dynamics in the Yellow Sea and so on, which enables her to enjoy a high reputation at home and abroad.

Marine science is an important science of the 21st century and needs the mutual efforts, close cooperation and creative work of the whole human society and scientific and technological circles at home and abroad. Hope that this pamphlet can help all walks of life to further understand our institute, promote her development and make still greater contributions to the development of marine science.

3.1.4 Presentation of Supervision and Test Center for Pesticide Safety Evaluation and Quality Control

Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC) was established in 1982 under a cooperative program supported by UNDP, UNIDO, and China's former Ministry of Chemical Industry. The Center conducts toxicological safety evaluation of drugs, pesticides, and other fine chemicals. The Center has conformed its organizational structure around GLP (Good Laboratory Practice), providing highly professional and technical staff, advanced instrumentation and equipments, a fully equipped set of facilities, and an excellent management system. All data and reports issued by the Center have been approved by relevant government agencies.

In 2004, PSEC received Ministry of Agriculture accreditation for agrochemical ecotoxicological safety evaluation. At the same time, PSEC was accredited for the testing of new chemicals. Later, in 2006, PSEC was accredited according to ISO/IEC 17025 by China National Accreditation Service for Conformity Assessment.

PSEC now performs ecological testing based on OECD Principles of Good Laboratory Practice and according to international standards. PSEC is registered as a GLP laboratory in P.R.C and receives regular inspections carried out by the state Food and Drug Administration and the Ministry of Agriculture, P.R.C. Its ecotoxicological laboratory performs standardized tests (e.g. in accordance with OECD, USEPA guidelines or ISO standards) as well as special services concerning toxicity, biodegradability and bioaccumulation of chemical substances, products and complex mixtures.

3.2 Responsibilities of Project Organization

Sunrui corrosion and fouling control company (SunRui CFCC): Responsible for operating of land-based set-up and the ballast water treatment system for testing, recording relative data of BalClor^{TM} BWMS. Responsible for Assisting other testing laboratories or companies to sampling and handling.

The First Institute of Oceanography, SOA (Center of Marine Environmental Measurement, The first institute of Oceanography, State Oceanic Administration): Responsible for measuring the environmental parameters (G8) and the physical and chemical properties (G9) of untreated and treated ballast water. Responsible for biological efficacy analysis (G8). Responsible for sampling, handling and measuring.

Pony Testing International Group: Responsible for the detection of chemical analysis (G9), hydrogen gas and chlorine gas, chemical substances including Active Substance, Relevant Chemical and Other Chemical. Responsible for sampling, handling and analyzing.

Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC) : Responsible for accomplishing aquatic toxicity tests. Responsible for sampling, handling and testing.

3.3 Personnel Responsibilities

Name: Guangzhou Liu
Technical title: Senior engineer
Major: Electrochemical Engineering
Organization: Sunrui Corrosion and Fouling Control Company
Responsibility: Responsible for organizing the tests, coordinating the testing organizations involved and field management.

Name: Qing Yu
Technical title: Doctor/engineer
Major: Ocean chemistry
Organization: Sunrui Corrosion and Fouling Control Company
Responsibility: Responsible for preparation of influent water and assisting the test organizations to sample.

Name: Haitao Wang
Technical title: Engineer
Major: Ocean chemistry
Organization: Sunrui Corrosion and Fouling Control Company
Responsibility: Responsible for assisting the test organizations to sample. Check the

quantities and serial number of samples.

Name: Xuelei Liu
Technical title: Engineer
Major: Electronic and electrical Engineering
Organization: Sunrui Corrosion and Fouling Control Company
Responsibility: Responsible for Cleaning land-based set-up and assisting the test organizations to sample.

Name: Zhilei Wang
Technical title: Engineer
Major: Electronic and electrical Engineering
Organization: Sunrui Corrosion and Fouling Control Company
Responsibility: Responsible for operation of ballast water treatment system.

Name: Hui Ding
Technical title: Engineer
Major: Applied chemistry
Organization: Sunrui Corrosion and Fouling Control Company
Responsibility: Responsible for record of operational parameters of facilities and concentration of TRO.

Name: Xin Liu
Technical title: Engineer
Major: Chemical engineering
Organization: Sunrui Corrosion and Fouling Control Company
Responsibility: Record the main process of tests by photograph.

Name: Baodong Wang
Technical title: Researcher
Major: Ocean chemistry
Organization: Center of Marine Environmental Measurement, The first institute of Oceanography, State Oceanic Administration, P.R.C
Responsibility: Responsible for assigning appropriate personnel to complete the environmental parameter, the physical and chemical properties and biological efficacy analysis task.

Name: Xia Sun
Technical title: Engineer
Major: Ocean chemistry
Organization: Center of Marine Environmental Measurement, The first institute of Oceanography, State Oceanic Administration, P.R.C

Responsibility: Responsible for measuring the environmental parameter and the physical and chemical properties of the untreated and treated ballast water. Responsible for sampling, handling and measuring.

Name: Linping Xie
Technical title: Engineer
Major: Ocean chemistry
Organization: Center of Marine Environmental Measurement, The first institute of Oceanography, State Oceanic Administration, P.R.C
Responsibility: Responsible for measuring the environmental parameter and the physical and chemical properties of the untreated and treated ballast water. Responsible for sampling, handling and measuring.

Name: Li Tian
Technical title: Engineer
Major: Oceanic biology
Organization: Center of Marine Environmental Measurement, The first institute of Oceanography, State Oceanic Administration, P.R.C
Responsibility: Responsible for biological analysis. Responsible for sampling, handling and measuring.

Name: Ping Sun
Technical title: Engineer
Major: Oceanic biology
Organization: Center of Marine Environmental Measurement, The first institute of Oceanography, State Oceanic Administration, P.R.C
Responsibility: Responsible for biological analysis. Responsible for sampling, handling and measuring.

Name:Jianwei Yu
Technical title: Senior Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for assigning appropriate personnel to complete chemical analysis, hydrogen and chlorine gas measurement task.

Name: Ping Wang
Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for sampling, handling and shipping for chemical analysis

Name: Xuedong Gao

Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for sampling, handling and shipping for chemical analysis

Name: Yuqiang Li
Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for sampling, handling and shipping for chemical analysis

Name: Mingming Jia
Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for sampling, handling and shipping for chemical analysis

Name: Fengwei Yue
Technical title: Engineer
Major: Applied chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for sampling, handling and measuring for chlorine gas measurement

Name: Xin Chu
Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for sampling and measuring for hydrogen gas measurement

Name: Jinjin Xiao
Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for Haloacetic acids testing.

Name: Xiangfei Sun
Technical title: Engineer
Major: Applied chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for Haloacetonitriles testing.

Name: Wei Wang

Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for Haloalkanes testing.

Name: Xiaodong Wang
Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for TRO, ClO^-(HClO), the total of Chloramines and Bromamines testing.

Name: Zeping Shi
Technical title: Engineer
Major: Applied chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for BrO^- (HBrO) testing.

Name: Zhonghua Li
Technical title: Engineer
Major: Applied chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for BrO_3^- testing.

Name: Yanli Jia
Technical title: Engineer
Major: Analytic chemistry
Organization: Pony Testing International Group Co., Ltd
Responsibility: Responsible for $S_2O_3^{2-}$ testing.

Name: Leiming Cai
Technical title: Director
Major: Environmental evaluation
Organization: Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC)
Responsibility: Responsible for aquatic toxicity test, sampling, handling and testing .

Name: Yanan Zhang
Technical title: Engineer
Major: Zoology toxicology
Organization: Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC)
Responsibility: Responsible for aquatic toxicity test, sampling, handling and testing

Name: Yinghui Wu
Technical title: Engineer
Major: Zoology toxicology
Organization: Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC)
Responsibility: Responsible for aquatic toxicity test, sampling, handling and testing

Name: Xiang Cai
Technical title: Engineer
Major: Zoology toxicology
Organization: Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC)
Responsibility: Responsible for aquatic toxicity test, sampling, handling and testing

4. Test Facility Description

4.1 Land-based set-up

Sunrui CFCC started the development of BWMS in 2006. A prototype BWMS with treatment capacity of 250m^3/h was designed and manufactured by the end of 2007.

In 2008, a land-based testing facility with flow rate of 250m^3/h was established in Qingdao in accordance with the IMO Guidelines (G8 Guidelines for Approval of Ballast Water Management Systems) (See Figure 2 and Figure 3). Preparation, installation and debugging of test facility were accomplished by Sunrui CFCC. Based on the testing and research work, the basic operational parameters of the BalClor^{TM} BWMS have been defined.

There are four simulated tanks in total, each with a volume of 250m^3. Two tanks (Culture tanks) are used for preparing the influent water to be tested. The other two tanks are used as holding tanks, one (Treated ballast tank) for storing treated water, and one (Control ballast tank) for keeping control water.

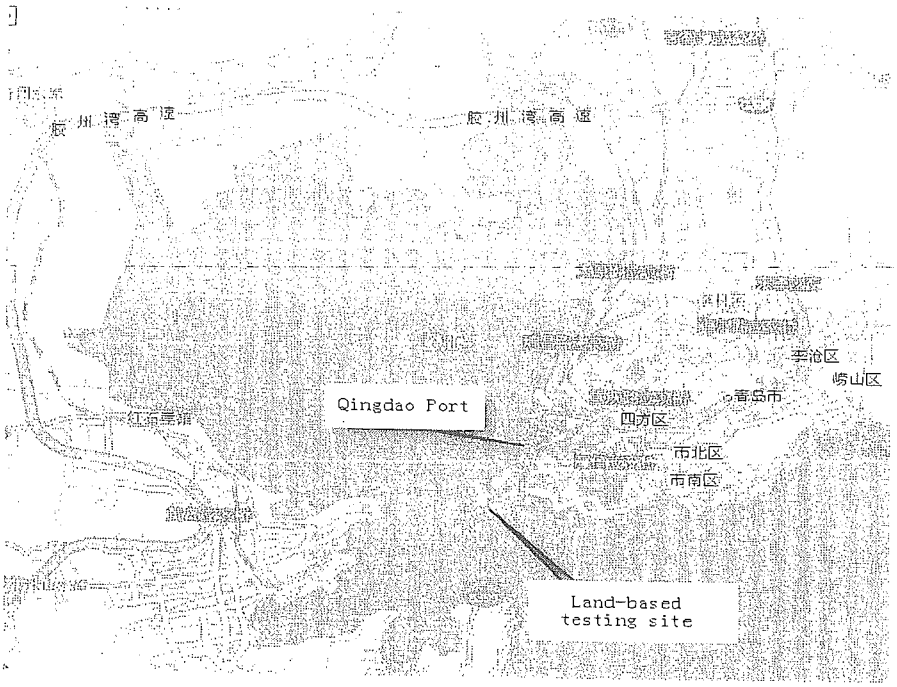

Figure 2 The location of land-based testing site

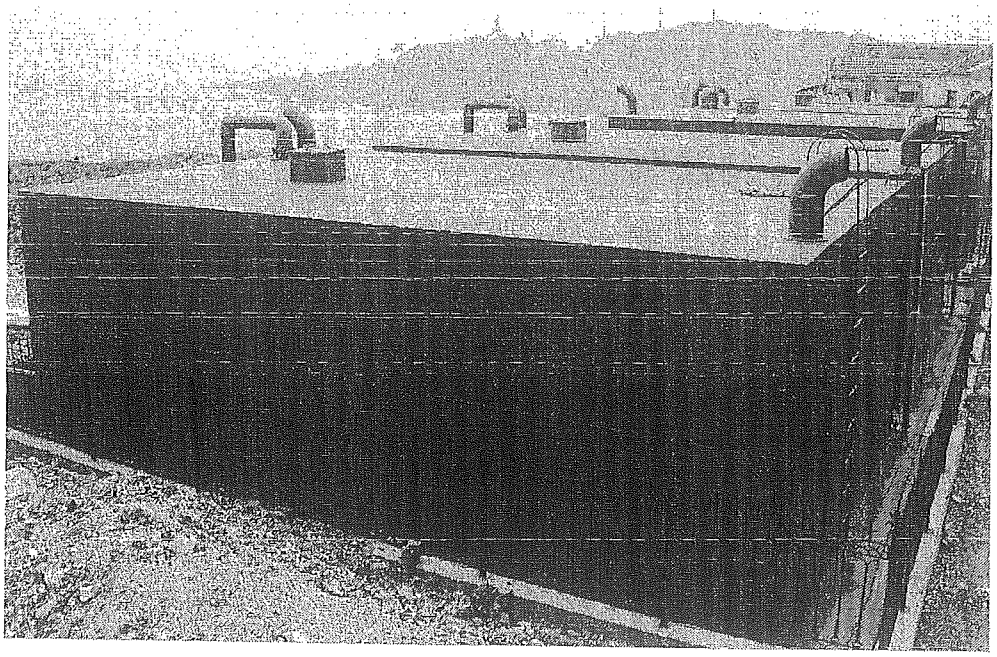

Figure 3 Land-based set-up（QINGDAO）

4.2 BalClorTM BWMS configuration

The BalClor^{TM} BWMS is an integrated system, which was established in accordance with the requirements of IMO Guidelines (G8) and the relevant requirements of the Class Rules. Rated

capacity of the full scale BalClor™ BWMS for testing is 250m^3/h. BalClor™ BWMS is comprised of the following functional modules:

- Self-cleaning filter (filtration precision is 50μm);
- Electrolytic unit (including electrolytic cells and accessory dosing and degassing units);
- Rectifier;
- Controller;
- TRO analyzer;
- Neutralizing unit;
- Sampling unit;
- Hydrogen gas / chlorine gas alarm.

The self-cleaning filter is a low-pressure type with 50μm, which is connected with the main ballast pipeline. When back-flushing, the ballasting process continues. The filter housing is carbon steel coated with epoxy coating, and the filter screen is made of duplex stainless steel, which is excellently resistant to seawater corrosion.

The water from the automatic back-flush operation is discharged overboard directly back to the sea area where it is taken. There is a bypass to the filter in the system. Figure 4 is a photograph of the self-cleaning filter.

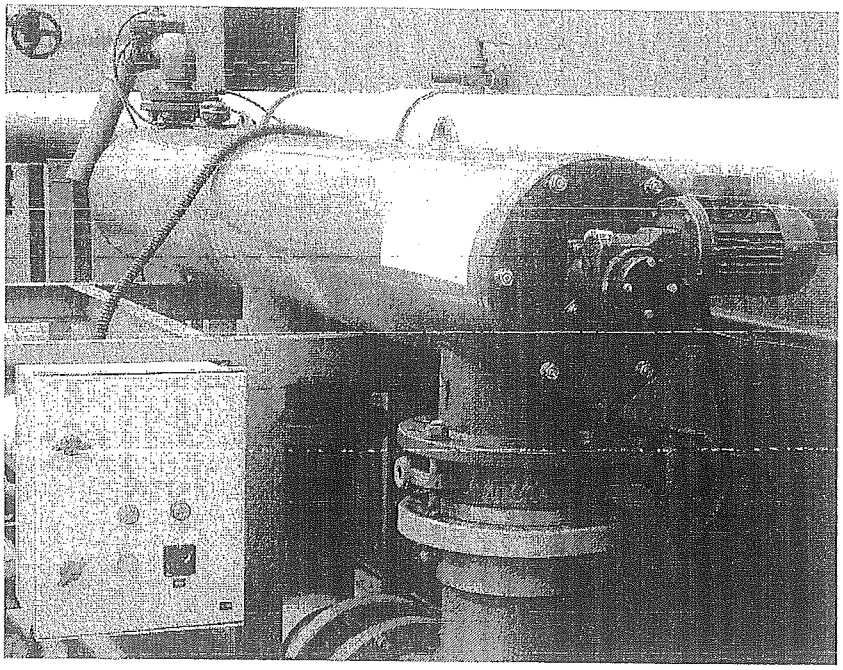

Figure 4 Self-cleaning filter

The electrolytic unit includes booster pump, flow-meters, electrolytic cells, degas tank (including air blowers), dosing pump, pipelines and valves, etc. The core component of electrolytic unit is electrolytic cell, which is comprised of cathode, anode and housing. The anodic material used in BalClor^{TM} BWMS is dimension stable anode (DSA), whose formula and manufacturing process are patented. The anodes are a sintered product of titanium coated by mixed noble metal oxides. The cathode is made of Hastelloy, and the housing of electrolytic cells is made of PVC with integral-forming technology, which greatly improves the strength of the housing. Figure 5 is a photograph of the electrolytic cells.

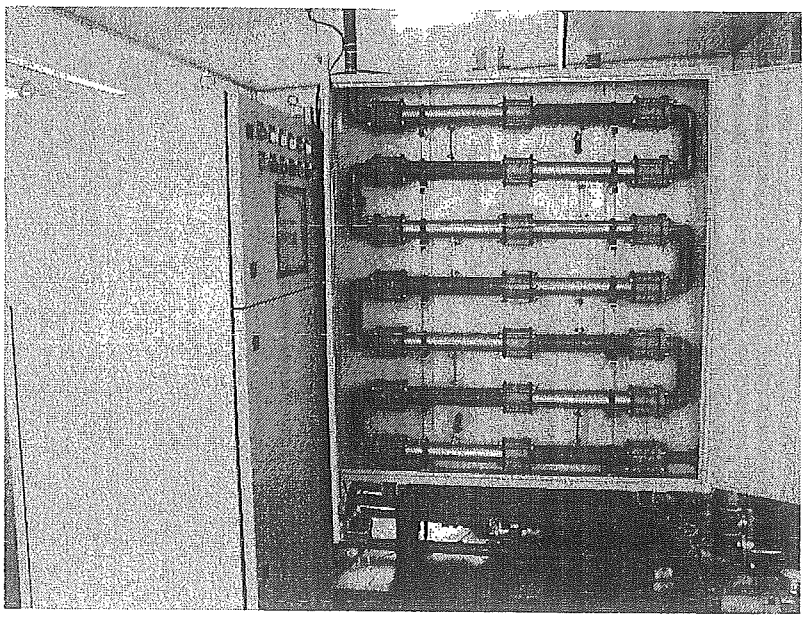

Figure 5 Electrolytic cells

High-frequency power technique helps the rectifier to increase its efficiency while reducing its volume and weight to decrease significantly, making the installation very convenient.

The controller consists of PLC (programmable logic controller), HMI (human-machine interface) and controlling circuits for electric facilities. Figure 6 is a photograph of control panel.

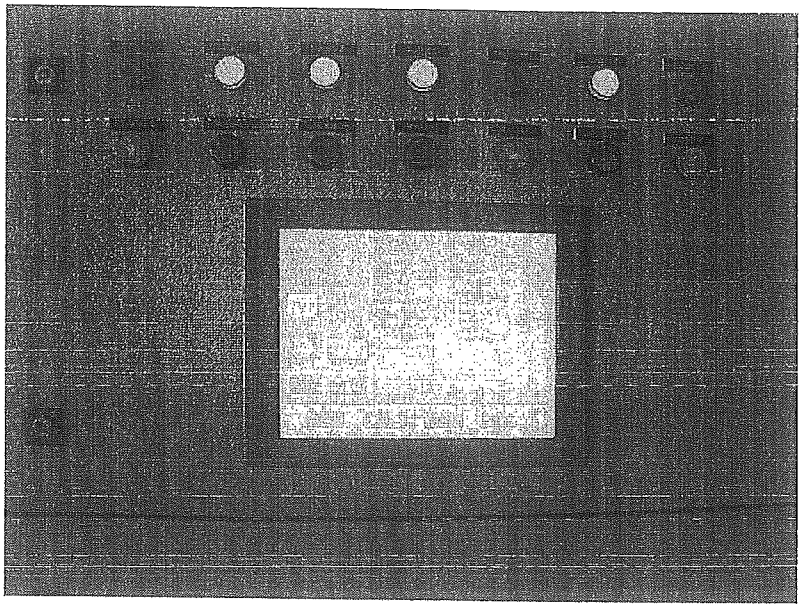

Figure 6 Control panel

TRO analyzer is the "eye" of the BalClor™ BWMS, also called water quality analyzer, is used to monitor the electric conductivity and TRO concentration of ballast water. The analyzer detects the TRO concentration in ballast water by DPD Sepctrophotometric Method. Figure 7 is a photograph of the TRO analyzer.

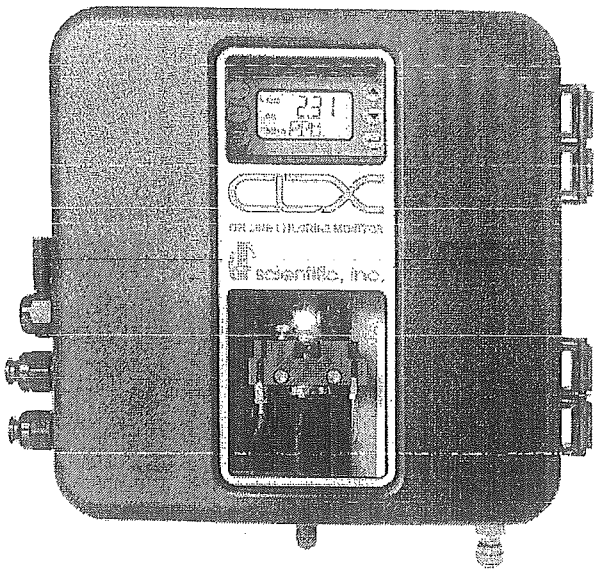

Figure 7 TRO analyzer

Neutralizing unit includes neutralizer tank, metering pump, pipelines and valves etc. The sodium thiosulfate solution is stored in neutralizer tank as the reductive agent. When de-ballasting, the metering pump, which is controlled by controller, injects certain amount of sodium thiosulfate solution into ballast water to neutralize the residual TRO in the water. Figure 8 is a photograph of the neutralizer tank.

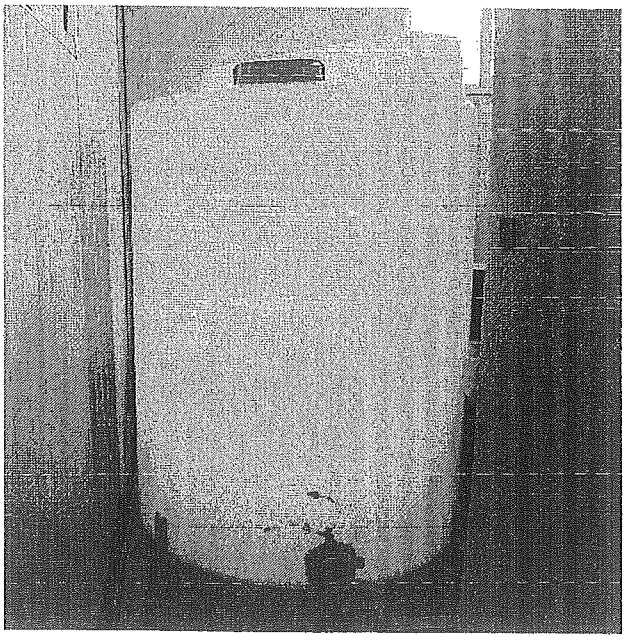

Figure 8 Neutralizer tank.

Sampling unit is designed and manufactured according to G8. It consists of sampling pump, sampling tank, pipelines and valves etc.

Hydrogen gas and chlorine gas alarm are installed around electrolytic unit. They are used to

detect individually the concentration of hydrogen gas and chlorine gas. The photographs of hydrogen gas and chlorine gas alarm are shown in Figures 9 and 10, respectively.

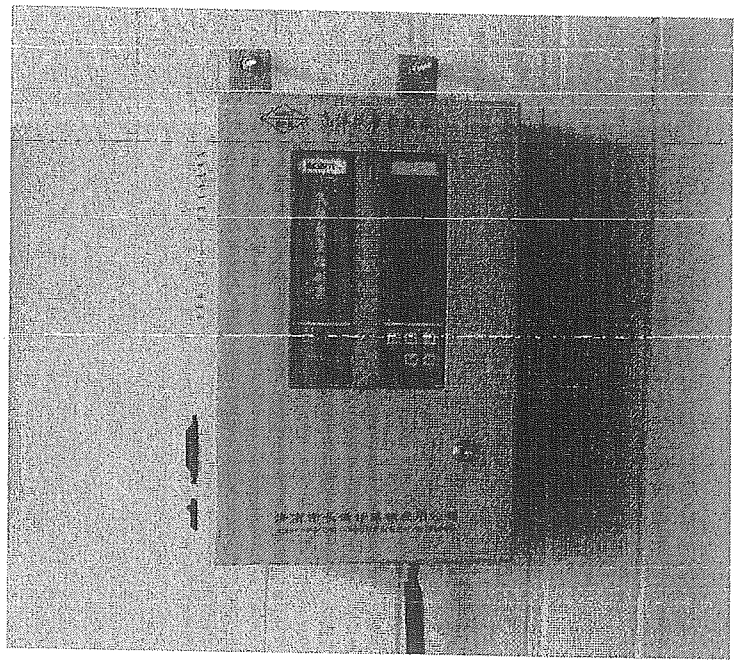

Figure 9 Hydrogen gas alarm

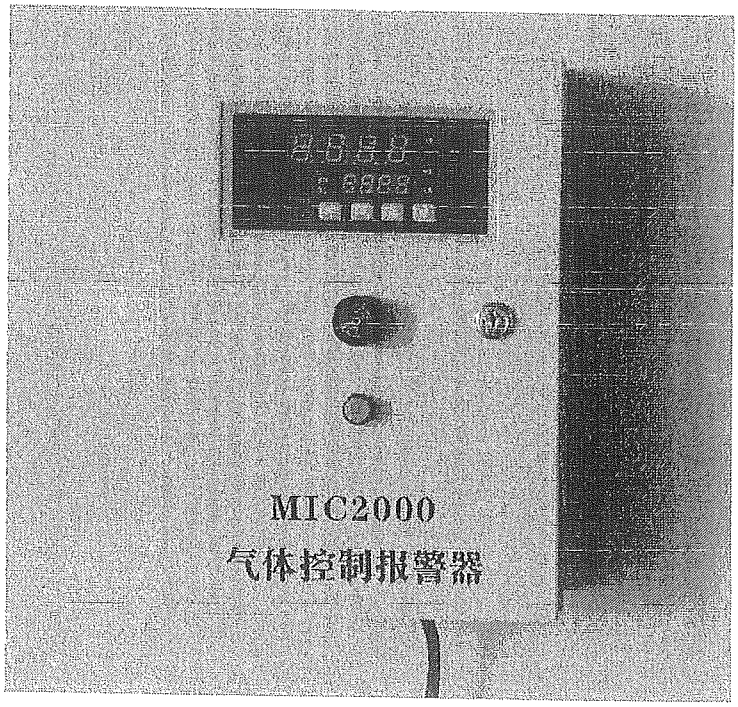

Figure 10 Chlorine gas alarm

The BalClor™ BWMS can be operated both automatically and manually. Under normal working condition, it operates in automatic mode. If necessary, the system can switch between automatic and manual operation modes.

5. Treatment Technology Description

The flow chart of treatment of BalClor^{TM} BWMS is shown in Figure 11 and Figure 12.

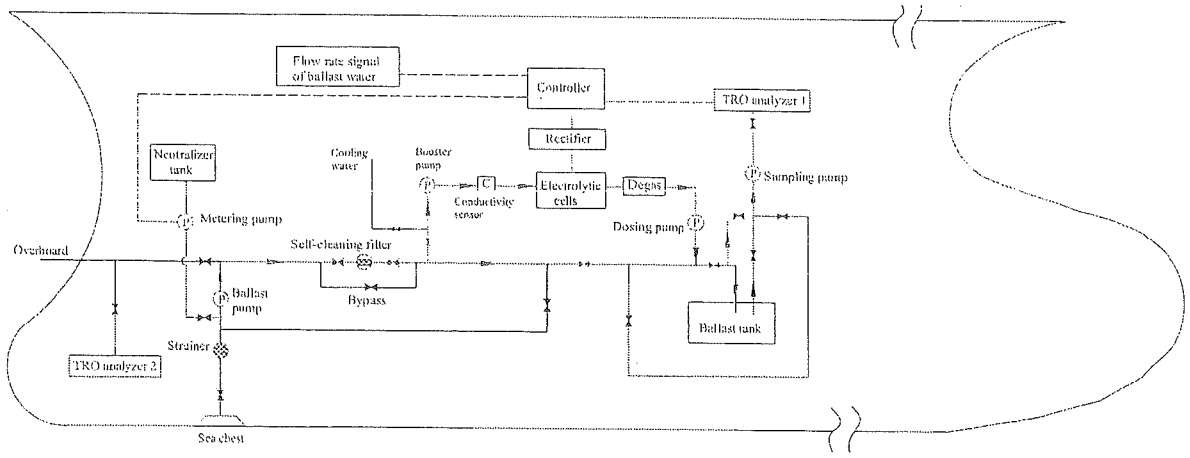

Figure 11 Ballasting

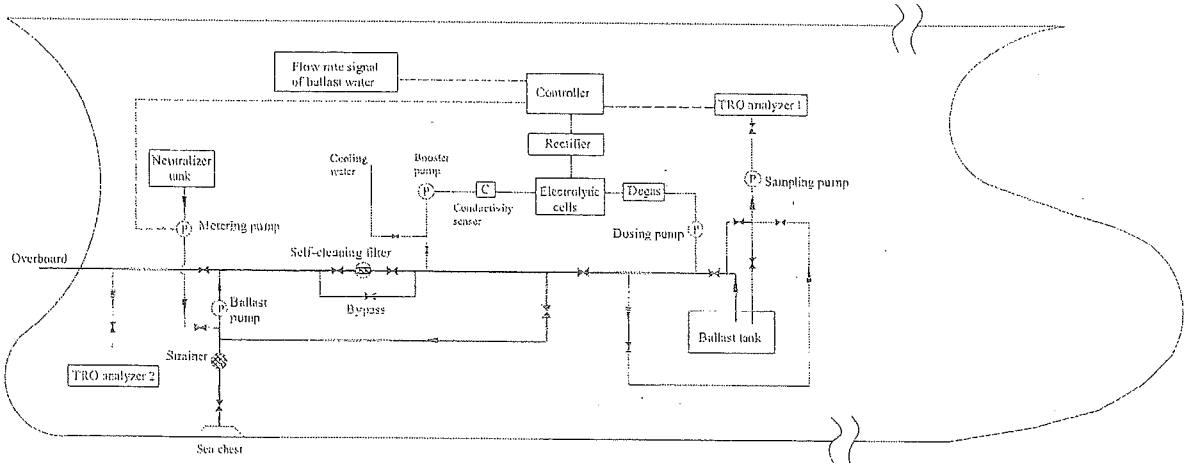

Figure 12 De-ballasting

When ballasting, seawater is filtrated by self-cleaning filter with precision of 50μm, then a side stream of seawater is pumped into an electrolytic unit to generate sodium hypochlorite solution, which is injected back into the main ballast stream after degas, and make a complete mixture with the main stream. The TRO level is measured by a TRO analyzer and controlled at a pre-set concentration value (ranging from 7.5 to 9.5 ppm, the default value is 7.5 ppm).

The SunRui electrochemical process employed a controlled electrolytic current to ensure that the dose of disinfectant to the ballast water make the TRO concentration at a preset level (7.5-9.5ppm). The current is adjusted automatically through a rectifier according to the signals

from the TRO analyzer, and then the TRO will be produced in proportion to the current to maintain the preset level. The flow chart of ballasting is shown in Figure11.

On discharge of the treated ballast water, the SunRui system monitors the levels of TRO in ballast water. Discharge does not start until the TRO analyzers and the neutralizer feed system are in operation. The neutralization system is activated with the neutralizer dosage being calculated from the concentration of TRO measured just before the neutralizer injection point, to offset the residual TRO. The sodium thiosulfate solution is injected into the suction side of the ballast pump by a metering pump. The TRO analyzer is also used to monitor the TRO level after neutralizer injection to ensure that during discharge TRO concentration does not exceed 0.1ppm at any time. The flow chart of de-ballasting is shown in Figure 12.

6. Land-based testing

6.1 A land-based test cycle should include

6.1.1 The uptake of ballast water by pumping with a flow rate of 200~300m^3/h;

6.1.2 The storage of treated ballast water for at least 5 days (120h);

6.1.3 The discharge of ballast water by pumping after neutralization with a flow rate of 200~300m^3/h.

6.2 The demand of salinity, the dissolved and particulate content in the influent water

The salinity, the dissolved and particulate content of the influent water used in the test set up

When land-based tests are conducted, the BalClor™ BWMS will be operated in accordance with the "Technical Specification and Manual".

The test water with two different salinity range (the high and medium salinity) will be used for land-based tests. The range of salinity and the requirement of dissolved and particulate content are listed in Table 1.

Table 1 The salinity range, the dissolved and particulate content of the influent water

	Salinity range	
	>32 PSU	3-22 PSU
Dissolved Organic Carbon (DOC)	>1mg/l	>5mg/l
Particulate Organic Carbon (POC)	>1mg/l	>5mg/l
Total Suspended Solids(TSS)	>1mg/l	>50mg/l

Five valid test cycles for each salinity range will be conducted, so ten valid test cycles in total will be conducted.

If natural seawater can not meet the requirement of the dissolved and particulate content mentioned above (in Table 1), some substances will be added to the test water. The content of DOC can be increased by adding the glucose. The content of POC can be improved by adding marine algae, sea mud and chitosan. Adding the sea mud can also enhance the content of TSS.

6.3 The test organisms in the influent water

6.3.1 Test organisms of greater than or equal to 50 micrometres or more in minimum dimension should be present in a total density of not less than 10^5 individuals per cubic metre, and should consist of at least 5 species from at least 3 different phyla/divisions.

6.3.2 Test organisms greater than or equal to 10 micrometres and less than 50 micrometres in minimum dimension should be present in a total density of not less than 10^3 individuals per millilitre, and should consist of at least 5 species from at least 3 different phyla/divisions.

6.3.3 Heterotrophic bacteria should be present in a density of at least 10^4 living bacteria per milliliter.

6.3.4 The variety of organisms in the test water should be documented according to the size classes mentioned above regardless if natural organism assemblages or cultured organisms were used to meet the density and organism variety requirements.

In case that the content of test organisms in natural seawater can not meet the requirements mentioned above, cultured organisms will be added to the test water and mixed uniformly in the feed tank. Cultured organisms will be provided by the first institute of Oceanography, State Oceanic Administration, P.R.C. When cultured test organisms are used, it should be ensured that local applicable quarantine regulation are taken into account during culturing and discharge.

6.4 The demand of the bacteria

The following bacteria do not need to be added to the influent water, but will be measured at the influent and at the time of discharge:

1 Coliform;

2 Enterococcus group;

3 Vibrio cholerae; and

4 Heterotrophic bacteria.

6.5 Cleaning of the test set-up

The test set-up should be pressure-washed with tap water, dried and swept to remove loose debris, organisms and other matter before starting testing procedures, and between test cycles.

6.6 Land-based monitoring and sampling

6.6.1 Change of numbers of test organisms by treatment and during storage in the simulated ballast tank should be measured.

6.6.2 It should be verified that the treatment equipment performs within its specified parameters during the test cycle, such as power consumption and flow rate, during the test cycle.

6.6.3 Environmental parameters such as pH, temperature, salinity, dissolved oxygen, TSS, DOC, POC and turbidity (NTU) should be measured at the time of sampling.

6.6.4 Samples during the test should be taken at the following times and locations: immediately before the treatment equipment, immediately after the treatment equipment and upon discharge.

6.6.5 The control and treatment cycles will be run sequentially. Control samples will be taken in the same manner as the equipment test as prescribed in paragraph 6.6.4 and upon influent and discharge.

6.6.6 Samples described in paragraphs 6.6.4 and 6.6.5 should be collected in triplicate on each occasion.

Separate samples should be collected for:

.1 organisms of greater than or equal to 50 micrometres or more in minimum dimension;

.2 organisms greater than or equal to 10 micrometres and less than 50 micrometres in minimum dimension;

.3 for coliform, enterococcus group, Vibrio cholerae and heterotrophic bacteria; and

.4 samples for toxicity testing, chemical analysis, physical and chemical properties tests of G9 tests.

6.6.7 For the comparison of organisms of greater than or equal to 50 micrometres or more in minimum dimension against the D-2 standard, at least 20 litres of influent water and 1 cubic metre of treated water, in triplicate respectively, should be collected. The samples are concentrated for enumeration, the samples will be concentrated using a sieve of 49.5 micrometres mesh in the diagonal dimension.

6.6.8 For the evaluation of organisms greater than or equal to 10 micrometres and less than 50 micrometres in minimum dimension, at least 1 litre of influent water and at least 10 litres of treated water should be collected. Samples are concentrated for enumeration using a sieve of 9.9 micrometres mesh in the diagonal dimension.

6.6.9 For the evaluation of bacteria, at least 500 millilitres of influent and treated water should be collected in sterile bottles.

6.6.10 The samples should be analysed as soon as possible after sampling, and analysed live within 6 hours or treated in such a way so as to ensure that proper analysis can be performed.

6.6.11 If in any test cycle the average discharge results from the control water is a concentration less than or equal to 10 times the values in regulation D-2.1, the test cycle is invalid.

6.6.12 Control water should be discharged after treatment by the BWMS so as to be in compliance with the local environmental protection requirements.

6.7 The test cycles

The tests on five cycles with high salinity and five cycles with medium salinity will be performed (See Table 2). Each cycle will last for a period of at least 5 days. In one test cycle for each salinity range, treated water will be also sampled for the toxicity tests and chemical tests required in G9.

In addition, one test on fresh water (Salinity<3PSU) will be conducted to analyze the chemicals in the water treated by electrolyze artificial saltwater.

The order of test cycles is as follows:

Table 2 Test cycles

Test cycles	Salinity range of test water	Note
TC01	>32 PSU	
TC02	>32 PSU	
TC03	>32 PSU	
TC04	>32 PSU	
TC05	3-22 PSU	
TC06	3-22 PSU	
TC07	>32 PSU	(1) (3)
TC08	3-22 PSU	(1) (3)
TC09	3-22 PSU	
TC10	3-22 PSU	
TC20	PSU < 3	(2) (3)

Note: (1) In test cycles TC07 and TC08, treated waters will be also sampled for the toxicity tests and chemical analysis tests required in G9.

(2) In test cycle TC20, saltwater is to be electrolyzed to produce TRO and inject into fresh water (PSU<3), and the treated water will be sampled for chemical analysis.

(3) The initial TRO will be set at the 9.5mg/L.

6.8 The flow chart of ballast water treatment and sampling points

The flow chart of ballast water treatment and sampling points of the test cycles (except for TC20) are shown in Figure 13-1.

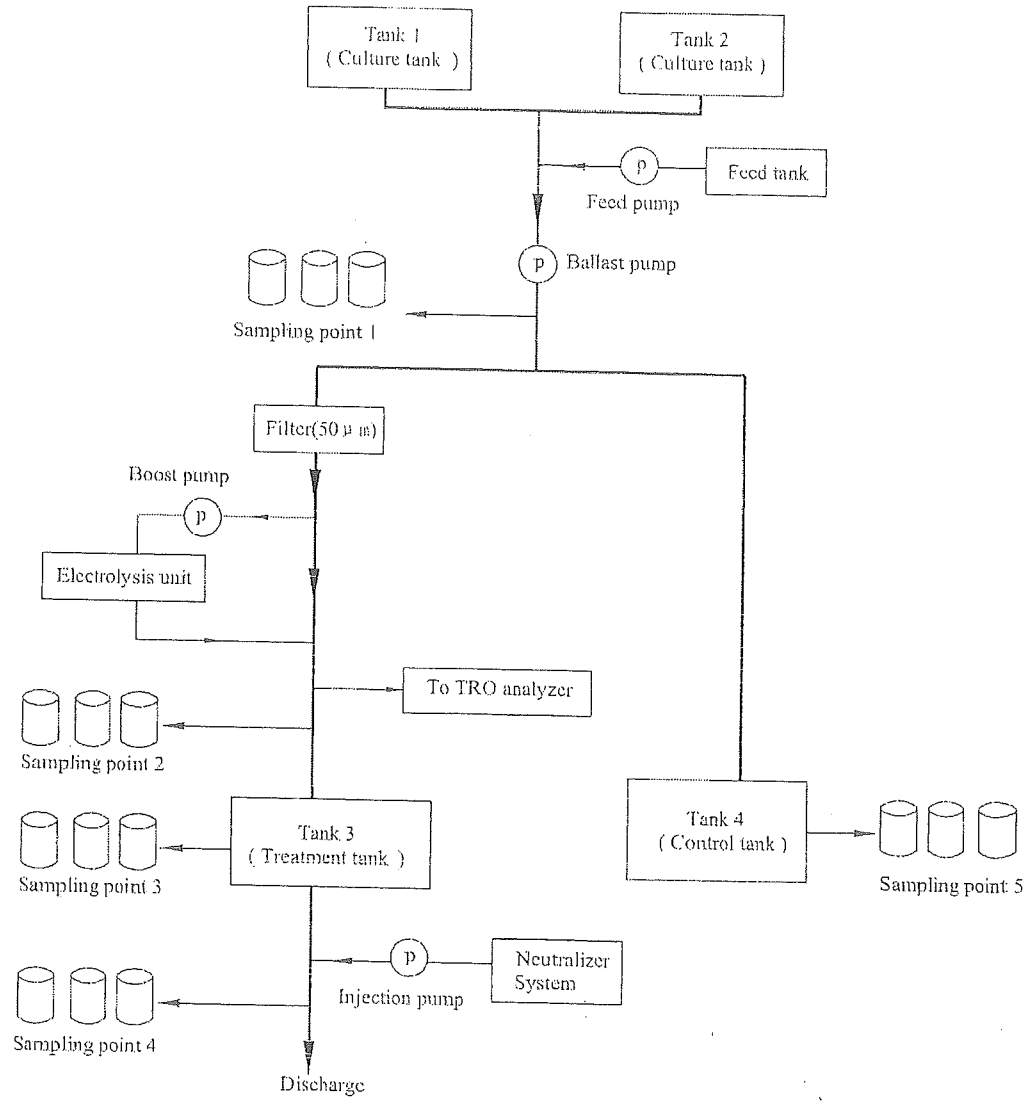

Figure 13-1 Flow chart of ballast water treatment and sampling points of the test cycles (TC01 – TC10)

To simulate ballasting in water with salinity below 3 PSU, one test (test cycle TC20) is designed to treat fresh water by electrolyzing saltwater. The chemical analysis will be performed to invest whether there would be any difference of the substances in the discharge waters between treated seawater and treated fresh water (by electrolyzing saltwater).

Before the test, saltwater is prepared with tap water by adding salt to make the salinity range 15-20PSU, and stored in a container. The test water (PSU < 3) is made up with tap water and natural seawater, and stored in two feed tanks, each tank with a capacity of 250m^3.

When running the test, the prepared saltwater will be pumped into the electrolysis unit for electrolyzing to produce TRO, which is injected into fresh water (PSU < 3). The flow chart of ballast water treatment and sampling points of test cycle TC20 are shown in Figure 13-2.

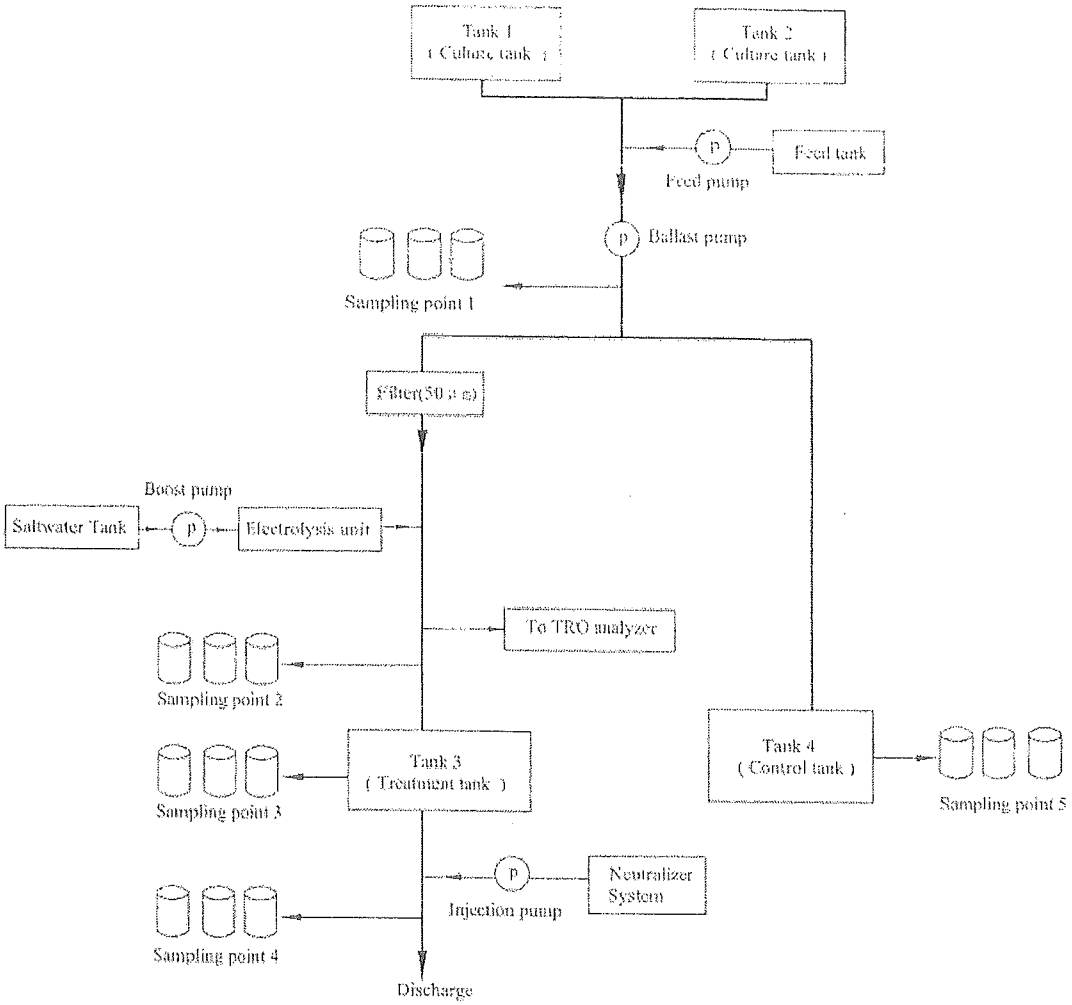

Figure 13-2 Flow chart of ballast water treatment and sampling points of test cycle TC20

6.9 Toxicity testing

In test cycles TC07 (with high salinity) and TC08 (with medium salinity), the discharge waters will be sampled immediately after treatment (after neutralizing) and after storage in tank for 48 hours (after neutralizing) for acute and chronic toxicity tests. The details are shown in Table 3:

Table 3 Samples for toxicity tests

Lot No.	Sampling description	Sampling points
20091101-TC07T-0h-N	100% ballast water treated by BalClor ™ BWMS: in high salinity test cycle, the influent water met requirement of G8, is treated by filter and electrolysis unit (TRO concentration: 9.5mg/L), and discharges immediately (neutralized by sodium thiosulfate, sampling at discharge).	Sampling point 4
20091103-TC07T-48h-N	100% ballast water treated by BalClor™ BWMS: in high salinity test cycle, the influent water met requirement of G8, is treated by filter and electrolysis unit (TRO concentration:	Sampling point 4

	9.5mg/L), and holds in treated tank for 48 hours, and discharges (neutralized by sodium thiosulfate, sampling at discharge).	
20091109-TC08T-0h-N	100% ballast water treated by BalClor™ BWMS: in medium salinity test cycle, the influent water met requirement of G8, is treated by filter and electrolysis unit (TRO concentration: 9.5mg/L), and discharges immediately (neutralized by sodium thiosulfate, sampling at discharge).	Sampling point 4
20091111- TC08T-48h-N	100% ballast water treated by BalClor™ BWMS: in medium salinity test cycle, the influent water met requirement of G8, is treated by filter and electrolysis unit (TRO concentration: 9.5mg/L), and holds in treated tank for 48 hours, and discharges (neutralized by sodium thiosulfate, sampling at discharge).	Sampling point 4

The following tests will be performed:

.1 growth inhibition test to marine algae;

.2 acute toxicity tests to marine fish;

.3 chronic toxicity tests to marine fish;

.4 acute toxicity tests to marine invertebrate;

.5 chronic toxicity tests to marine invertebrate.

Toxicity tests will be performed by Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC) in Shenyang.

6.10 Chemical analysis

Samples for chemical analysis will be taken in test cycles TC07, TC08 and TC20. Sampling points and descriptions are shown in Table 4, Table 5 and Table 6.

Table 4 Samples for chemical analysis in test cycle TC07 (salinity＞32 PSU)

Lot No.	Samples description	Sampling points
20091101-TC07T-INF	The influent water, added cultured organisms, DOC, POC and TSS, its contents meet the requirements of G8.	Sampling point 1.
20091101-TC07T-0h	Test water treated by filter and electrolysis unit, and immediately sampling from treated tank (non-neutralizing).	Sampling point 3.
20091101-TC07T-0h-N	Test water treated by filter and electrolysis unit, and immediately sampling from treated tank (after neutralizing).	Sampling point 4.

20091101-TC07C-0h	Test water (control).	Sampling point 5.
20091102-TC07T-24h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 24h (non-neutralizing).	Sampling point 3.
20091103-TC07T-48h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 48h (non-neutralizing).	Sampling point 3.
20091103-TC07T-48h-N	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 48h (after neutralizing).	Sampling point 4.
20091103-TC07T-48h-N-48h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 48h (after neutralizing), then holding another 48h.	Sampling point 4.
20091106-TC07T-120h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 120h (non-neutralizing).	Sampling point 3.
20091106-TC07T-120h-N	Test water treated by filter and electrolysis unit, and holding in treated tank for 120h , sampling at discharge (after neutralizing).	Sampling point 4.
20091106-TC07C-120h	Test water holding in control tank for 120h, sampling at discharge.	Sampling point 5.

Table 5 Samples for chemical analysis in test cycle TC08 (salinity 3-22 PSU)

Lot No.	Samples description	Sampling points
20091109-TC08T-INF	The influent water, added cultured organisms, DOC, POC and TSS, its contents meet the requirements of G8.	Sampling point 1.
20091109-TC08T-0h	Test water treated by filter and electrolysis unit, and immediately sampling from treated tank (non-neutralizing).	Sampling point 3.
20091109-TC08T-0h-N	Test water treated by filter and electrolysis unit, and immediately sampling from treated tank (after neutralizing).	Sampling point 4.
20091109-TC08C-0h	Test water (control).	Sampling point 5.
20091110-TC08T-24h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 24h (non-neutralizing).	Sampling point 3.
20091111-TC08T-48h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 48 h (non-neutralizing).	Sampling point 3.
20091111-TC08T-48h-N	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 48 h (after neutralizing).	Sampling point 4.
20091111-TC08T-48h-N-48h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 48 h (after neutralizing), then holding another 48h.	Sampling point 4.

20091114-TC08T-120 h	Test water treated by filter and electrolysis unit, and sampling from treated tank after holding 120h (non-neutralizing).	Sampling point 3.
20091114-TC08T-120 h-N	Test water treated by filter and electrolysis unit, and holding in treated tank for 120h, sampling at discharge (after neutralizing).	Sampling point 4.
20091114-TC08C-12 0h	Test water holding in control tank for 120h, sampling at discharge.	Sampling point 5.

Table 6 Samples for chemical analysis in test cycle TC20 (salinity < 3 PSU)

Lot No.	Samples Description	Sampling points
20091211-INF	The influent water, with salinity below 3 PSU in electrolyzing saltwater test cycle, is prepared with tap water and seawater, and meets the requirements (DOC, POC, TSS) of G8 by adding glucose, chitosan and sea mud and so on.	Sampling point 1
20091211-0h	Freshwater is treated by filter and electrolysis unit, and immediately sampling from treated tank (non-neutralizing), in treatment cycle.	Sampling point 3
20091212-24h	Freshwater is treated by filter and electrolysis unit, and sampling from treated tank after holding 24h (non-neutralizing), in treatment cycle.	Sampling point 3
20091213-48h	Freshwater is treated by filter and electrolysis unit, and sampling from treated tank after holding 48h (non-neutralizing), in treatment cycle.	Sampling point 3
20091213-48h-N	Freshwater is treated by filter and electrolysis unit, and sampling from treated tank after holding 48h (after neutralizing), in treatment cycle.	Sampling point 4
20091213-48h-N-48h	Freshwater is treated by filter and electrolysis unit, and sampling from treated tank after holding 48h (after neutralizing), then holding another 48h, in treatment cycle.	Sampling point 4
20091216-120h-N	Freshwater is treated by filter and electrolysis unit, and holding in treated tank for 120h, sampling at discharge (after neutralizing), in treatment cycle.	Sampling point 4
20091216-C-120h	Freshwater is holding in control tank for 120h, sampling at discharge, in control cycle.	Sampling point 5

Test items and quantitation limits for chemical analysis are shown in Table 7.

Table 7 List of Test Items and Quantitation Limits for Chemical Analysis

Number	Test Items	Quantitation limit (μg/L)
1	Hypochlorous acid	40
2	Hypobromous acid	6
3	Chloramines/Bromamines	40
4	Trichloromethane	0.02

5	Dibromomethane	0.02
6	Bromodichloromethane	0.03
7	Dibromochloromethane	0.02
8	Tribromomethane	0.03
9	1,2-dibromoethane	0.02
10	1,2,3-Trichloropropane	0.02
11	1,2-Dibromo-3-Chloropropane	0.03
12	Trichloroacetic acid	0.03
13	Bromodichloroacetic acid	0.03
14	Monochloroacetic acid	0.02
15	Monobromoacetic acid	0.02
16	Dichloroacetic acid	0.03
17	Bromochloroacetic acid	0.03
18	Dibromoacetic acid	0.03
19	Dibromochloroacetic acid	0.03
20	Tribromoacetic acid	0.03
21	Dibromoacetonitrile	0.01
22	monobromoacetonitrile	0.01
23	Trichloroacetonitrile	0.01
24	Dichloroacetonitrile	0.01
25	Bromochloroacetonitrile	0.01
26	Bromate ion	0.4
27	Sodium thiosulphate	20

Chemical analysis will be performed by Pony Testing International Group Co., Ltd (Pony

Test).

6.11 Physical and chemical properties tests

The physical and chemical properties of all samples for chemical analysis and toxicity test will be tested, including pH, temperature, salinity, dissolved oxygen, TSS, DOC, POC, turbidity(NTU), relative density and Oxidation/reduction potential. The tests will be performed by the First Institute of Oceanography, SOA (Center of Marine Environmental Measurement).

6.12 Measurement of hydrogen gas and chlorine gas

In test cycle 07 and 08, the concentration of hydrogen gas will be detected in three locations: in the surrounding of the BalClor^{TM} BWMS, the headspace of treated tank and upon discharge of vent pipe of degas tank. The concentration of chlorine gas will be detected in two locations: in the surrounding of the BalClor^{TM} BWMS and the headspace of treated tank.

Sampling locations and time intervals are shown in Table 8, 9, 10, 11 and 12.

Table 8 Hydrogen gas measurements in the surrounding of the BalClor^{TM} BWMS

Test time	Concentration of hydrogen gas in the surrounding of BWMS, v/v %
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	
24h after the end of electrolysis	

Table 9 Hydrogen gas measurements in the headspace of treated tank

Test time	Concentration of hydrogen gas in the headspace of treated tank, v/v %
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	

2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	
12h after the end of electrolysis	
24h after the end of electrolysis	
48h after the end of electrolysis	
72h after the end of electrolysis	
96h after the end of electrolysis	
120h after the end of electrolysis	

Table 10 Hydrogen gas measurements upon discharge of vent pipe of degas tank

Test time	Concentration of hydrogen gas upon discharge of vent pipe of degas tank, v/v %
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	

Table 11 Chlorine gas measurements in the surrounding of the BalClor^{TM} BWMS

Test time	Concentration of chlorine gas in the surrounding of BWMS, mg/m^3
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	

24h after the end of electrolysis	

Table 12 Chlorine gas measurements in the headspace of treated tank

Test time	Concentration of chlorine gas in the headspace of treated tank, mg/m^3
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	
12h after the end of electrolysis	
24h after the end of electrolysis	
48h after the end of electrolysis	
72h after the end of electrolysis	
96h after the end of electrolysis	
120h after the end of electrolysis	

Hydrogen and Chlorine gas measurements will be conducted by Qingdao lab of Pony Test.

6.13 Measurement concentration of TRO in treated and control tank

In test cycle 07 and 08, the changes of TRO concentrations over time in treated tank and control tank will be measured and recorded. Sampling points and time intervals are shown in Table 13.

Table 13 The decay of TRO concentration in treated tank and control tank

Time interval		0h	12h	24h	48h	72h	96h	120h
TRO concentration , mg/L	treated tank							
	control tank							

The measurements of TRO decay will be conducted by Qingdao lab of Pony Test.

6.14 Toxicity testing items and guidelines

Toxicity testing items and guidelines are shown in Table 14.

Table 14 Toxicity testing items and guidelines

Test species	Test items	Samples	Methods
(*Skeletonema costatum*) Algae	Chronic	20091101-TC07T-0h-N 20091103-TC07T-48h-N 20091109-TC08T-0h-N 20091111- TC08T-48h-N	EPA OPPTS 850.5400
(*Neomysis awatschensis*) Invertebrate	Acute		EPA method 2007.0
	Chronic		EPA OPPTS 850.1350
(*Ctenogobius gymnauchen*) Fish	Acute		EPA method 2004.0
	Chronic		EPA method 1006.0

6.15 Sampling, handling and storage of samples for chemical analysis

All the samples must be sealed in brown glass containers, and the closures are made of PTFE material. Pretreatment: Clean the vials and closures with detergent and running water, and then clean them with deionized water twice. After natural drying at room temperature, put the vials in 400°C muffle for 60 minutes, then natural drying at room which has no organic matter. Clean the closures with acetone and put them in 80°C oven for 1 hour.

In order to maintain the stability of the content in samples to be measured, different reagents will be added to the samples to make the components stable according different testing items when sampling in accordance with the requirements of the standard methods. The brown glass bottles of 4L with PTFE cap will be used, the bottles will be full with no headspace during the sampling. The kind and dosage of additive reagents are shown in Table 15:

Table 15 The reagents to be added when sampling

Test items	The reagents to be added (for 4L/ bottle)
Active substance	None
Sodium thiosulphate	None
Bromate ion	Ethylenediamine solution (100mg/ml): 2ml
Haloalkanes	$Na_2S_2O_3$: 0.32g
Haloacetic acids	NH_4Cl: 0.4g

Haloacetonitriles	NH_4Cl: 0.4g Na_2HPO_4: 0.67g KH_2PO_4: 66g

The concentration of active substances will be measured in Qingdao lab of Pony Test within one hour after sampling. And the samples for other items will be sent to Beijing lab of Pony Test by automobile with air conditioner within 9 hours. Samples will be refrigerated at 0~4°C, sealed and preserved with no headspace in the dark. The requirements are shown in Table 16.

Table 16 Analytical method, containers, preservation, and holding times requirements for chemical analysis

Analytical Parameter	**Reference method**	**Containers**	**Preservation Requirements**	**Maximum Holding Times**
Haloalkanes	EPA524.2	Brown glass bottle with PTFE material stopper	4℃, lucifuge, seal, No headspace	9h
Haloacetic acids	EPA552.3	Brown glass bottle with PTFE material stopper	4℃, lucifuge, seal, No headspace	9h
Haloacetonitriles	EPA551.1	Brown glass bottle with PTFE material stopper	4℃, lucifuge, seal, No headspace	9h
TRO HClOl(ClO^-) Chloramines and Bromamines	EPA330.5 GB/T 5750.11-2006 4500-Cl G. (STANDARDMETHODS FOR THE EXAMINATION OF WATER & WASTEWATER 21st Edition)	Brown glass bottle with PTFE material stopper	4℃, lucifuge, seal, No headspace	1h
HBrO(BrO^-)	PONY-BJXZSZ037-2009A	Brown glass bottle with PTFE material stopper	4℃, lucifuge, seal, No headspace	1h
Sodium thiosulphate	PONY-BJXZSZ038-2009A	Brown glass bottle with PTFE material stopper	4℃, lucifuge, seal, No headspace	9h
Bromate ion	EPA317.0	Brown glass bottle with PTFE material stopper	4℃, lucifuge, seal, No headspace	9h

Note: Maximum Holding Times: From sampling to analysis

6.16 Sampling, handling and storage of samples for aquatic toxicity tests

The samples should be stored at 0-4°C in refrigeratory in the dark with no headspace with blue PE plastic barrels, immediately transported to Supervision and Test Center for Pesticide Safety Evaluation and Quality Control (PSEC) by truck with air conditioner, and the test should be started within 23h from sampling.

6.17 Analytical methods for physical and chemical properties tests

Analytical methods for physical and chemical properties tests are shown in Table 17.

Table 17 Analytical methods for physical and chemical properties tests

Analytical Parameter	Methods
Temperature	GB 17378.4-2007 Pages 79-80
Salinity	GB 17378.4-2007 Pages 92-95
Total Suspended Solids	GB 17378.4-2007 Pages 88-91
Dissolved Oxygen	GB 17378.4-2007 Pages 99-101 GB/T 12763.4-2007 Pages 7-10
pH	GB 17378.4-2007 Pages 83-88. GB/T 12763.4-2007 Pages 10-12
Turbidity	GB 17378.4-2007 Pages 98-99
Dissolved Organic Carbon	GB 17378.4-2007 Pages 105-107
Particulate Organic Carbon	GB 17378.4-2007 Pages 105-107
Oxidation/Reduction Potential	GB17378.5-2007 pages 55-56
Relative Density	ASTM. D 4052-96

7. Quality Assurance Project Plan

QAPP for environmental parameters, physical and chemical properties tests and biological efficacy analysis of treated water will be developed by The First Institute of Oceanography, SOA. The concrete content will be shown in QAPP.

QAPP for chemical analysis, TRO decay and hydrogen and chlorine gases measurement will

be developed by Pony Testing International Group. The concrete content will be shown in QAPP.

QAPP for aquatic toxicity tests will be developed, and protocols for each test will be stipulated by Supervision and Test Center for Pesticide Safety Evaluation and Quality Control. The concrete content about aquatic toxicity tests will be shown in QAPP.

8 Data management

Any data collected during testing activities must be capable of withstanding challenges to its validity, accuracy, and legibility. Data will be recorded in standardized formats and in accordance with the following requirements:

Data are entered directly, promptly, and legibly.

Data are recorded legibly in ink. All original data records include, as appropriate, a description of the data collected, the unit, the unique sample identification, the name of the person collecting the data, and the date and time of data collection.

Any changes to the original entry do not obscure the original entry, document the reason for the change, and are initialed and dated by the person making the change.

All deviations from the QAPP must be documented in writing, and approved by the appropriate authority.

9 Standards and Guidelines

9.1 Guidelines for biological analysis

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10. Experiment procedure

10.1 Preparation for experiments

10.1.1 Cleaning test set-up

The test set-up should be pressure-washed with tap water, dried and swept to remove loose debris, organisms and other matter before starting test, and between test cycles.

The automatic self-cleaning filter should be back-washed by manual mode before starting test, and between test cycles.

10.1.2 Preparation for influent water

Some relevant substances will be added to the test water in according with the influent water requirements of G8. The details are shown as follows:

Adjustment of salinity of influent water: According to the requirements of G8, the salinity of influent water will be adjusted by adding salt or tap water into natural seawater.

Dissolved Organic Carbon (DOC): The content of DOC will be improved by adding the glucose into test water.

Particulate Organic Carbon (POC): The content of POC will be improved by adding marine algae and chitosan.

Total Suspended Solids (TSS): The content of TSS will be improved by adding sea mud.

The cultured organisms added in the influent water will be provided by Center of Marine Environmental Measurement, The first institute of Oceanography, State Oceanic Administration, P.R.C.

10.2 Operation of test facilities during ballasting and discharge

10.2.1 Operation of test facilities during ballasting

10.2.1.1 Preparation of pipeline

- Open the inlet valve of the treated tank and close the inlet valves of feed tank 1and 2 and control tank;
- Check the water level of feed tank;
- Open the outlet valves of feed tank 1 and 2.

10.2.1.2 Facilities operation when ballast

- Close the air switch of the main power;
- Open the front door of controller, and close all air switches, and close the door of controller;
- Start the touch screen and enter human-machine interface (HMI) automatically;

- The BalClor™ BWMS will perform self-checking, including all sensors and meters. If there are any faults, the alarm will be triggered;
- Preset the concentration of TRO or use the default value (7.5mg/L);
- When the BalClor™ BWMS is ready, click on "ballast" button to start the ballast pump. And observe and adjust the flow rate of main pipeline to ensure that the flow rate is within the specified range, then, the ballast will start;
- When the treatment is finished, click on "stop" button to stop the ballast pump, and the BalClor™ BWMS will stop automatically.
- Open the front door of controller after finishing process and disconnect all the air switches. Disconnect the main power switch;
- Close the outlet valve of feed tank and inlet valve of treated tank.

10.2.2 Operation of test facilities during discharge

10.2.2.1 Preparation of pipeline

- Open the outlet valve of treated tank and pipeline;
- Check the water level of neutralizer tank.

10.2.2.2 Facilities operation when discharge

- Close the air switch of the main power;
- Open the front door of controller, and close all air switches, and close the door of controller;
- Start the touch screen and enter human-machine interface (HMI) automatically;
- The BalClor™ BWMS will perform self-checking, including all sensors and meters. If there are any faults, the alarm will be triggered;
- When the BalClor™ BWMS is ready, click on "ballast " button to start the ballast pump. And observe and adjust the flow rate of main pipeline to ensure that the flow rate is within the specified range. The flow of the neutralizer will be regulated automatically, according to the flow rate of main pipeline and measured concentration of TRO by TRO analyzer;
- When the treatment is finished, click on "stop" button to stop the ballast pump, and

the BalClor™ BWMS will stop automatically.

- Open the front door of controller after finishing process and disconnect all the air switches. Disconnect the main power switch;
- Close the outlet valve of treated tank.

10.3 Sampling time

All the samples should be taken after the BWMS is in stable operation for more than 10 minutes.

11 Experiment records

11.1 Record of the operational parameters of BWMS during treatment

The operational parameters of ballast water treatment system should be recorded, including the flow rate of main pipelines, electrolytic current, voltage of electrolyzers, the flow rate to electrolyzers, concentration of TRO in main pipelines during the treatment and discharge and the dosage of neutralizer, etc.

11.2 Record of sampling and test items for environmental parameter tests

Information about sampling time, sampling volume and test items for environmental parameter tests should be recorded.

11.3 Record of sampling for biological analysis

The sampling process for different size plankton and bacteria should be recorded.

11.4 Record of the TRO concentration decay in the tanks

The concentration of TRO in treated tank should be measured and recorded daily for test cycle 01 to 10, and for test cycle 07 and 08, the concentration of TRO in control tank should be recorded as well.

11.5 Record of sampling process for aquatic toxicity tests

Sampling process for toxicity tests should be recorded in test cycle 07 and 08.

11.6 Record of sampling process for chemical analysis

Sampling process for chemical analysis should be recorded in test cycle 07, 08 and 20.

11.7 Record of sampling process for physical and chemical properties tests

Physical and chemical properties of all samples for chemical analysis should be tested, and the sampling process should be recorded.

11.8 Record of sampling for hydrogen and chlorine gas measurement

Sampling process for hydrogen and chlorine gas measurement should be recorded in test cycle 07 and 08.

11.9 The rule for numbering of samples

Taken the test cycle 07 as example, the rule for numbering of samples is as follows:

- 20091101: Sampling date;
- TC07T: Treatment cycle of test cycle 07;
- TC07C: Control cycle of test cycle 07;
- INF: Influent water;
- IAT: Immediately after treatment equipment;
- DIS: Discharge;
- EP: For environmental parameter measurement;
- 50u: For biological analysis of organisms of greater than or equal to 50 micrometres or more in minimum dimension;
- 10u: For biological analysis of organisms greater than or equal to 10 micrometres and less than 50 micrometres in minimum dimension;
- Het: For biological analysis of heterotrophic bacteria;
- Col: For biological analysis of coliform;
- Ent: For biological analysis of enterococcus group;

- Vch: For biological analysis of Vibrio cholerae.
- 1，2，3: For triplicate on each occasion.

12. Emergency plan

12.1 Disruption of electricity

Contact the power management department before experiments and check the circuitry to ensure that power should be supplied normally during experiment.

If a sudden power failure happens during experiment, contact the personnel of power management immediately to make sure the causes of power failures: normal power failure or a sudden electrical fault. If the power does still not supply before 4:00 pm this day, the experiment will be postponed to the next day. If the power outage is more than a day or even longer, to wait until the power supply normally to continue experiment.

12.2 Ballast pump does not work

Ballast pump should be maintained regularly in accordance with the maintenance requirements to ensure that ballast pump be always in normal state. If the ballast pump does not work during experiments suddenly, stop experiment and contacted the manufacturer immediately. Request for technical maintenance personnel to reach the test site within two days. Continue the test after getting rid of troubles.

13. Safety measures

All those involved should have distinct division of work. If emergency happens, immediately report to on-site director who will constitute viable programs to resolve emergency.

In addition, all those involved should also comply with the following items:

13.1 Electrical safety

Power supply and electrical equipments should be started and operated by professionals, and other personnel must not operate. Power supply should be cut off firstly if the equipment needs to be connected to electricity or maintained. The professionals should work under the conditions of insulation. Regardless of what kind of reason, if the personnel receive an

electric shock, the other personnel should cut off the power supply immediately to avoid serious personal injury or casualty.

13.2 Fire disaster

When fire happens, personnel should quickly report to the project manager, and cut off the power supply immediately, and extinguish fire according to predetermined programs. The personnel should immediately call "119", tell them the fire size and fire material, and then send persons to pick up fire company at the crossing. The injured people should be sent to hospital or calling 120 emergency centers to make first aid.

13.3 To prevent high-altitude fall

Persons should stand in the middle of the top of tanks when need to work on the top of the tanks. Unrelated persons are prohibited to stand on the top of tanks. All persons are prohibited to jump directly from a tank to another.

Some persons who need to work on the dam should prevent from falling into the sea or ballast pump hole. If the wind is large, all persons should be prohibited to work on the dam.

13.4 Safety instructions of chemical reagents

The persons should wear PPE/RPE to prepare the solution of sodium thiosulfate. If the solution of sodium thiosulfate splashes on the skin, the persons should rinse with tap water immediately.

13.5 Prevention of knock and bump

There are many steel frames with many edges and corners in the test space. So the personnel should improve self-protection consciousness and prevent from bruising.

13.6 Training for safety

All persons should be trained for safety before the start of tests.

14 Appendixes

Tables of Experimental Records

Table 1 The records of operational paramcters of BWMS （G8）

TEST CYCLE: _____

Test time	Flow rate of main pipeline (m^3/h)	Electrolytic current (A)	Voltage of electrolyzers (V)	Flow rate to electrolyzers (m^3/h)	Concentration of TRO in main pipelines during ballasting （mg/L）	Concentration of TRO in main pipelines during discharge （mg/L）	Dosage of neutralizer
0h							
10min							
20min							
30min							
40min							
50min							
60min							
70min							

Recorder: Supervisor:

Date: Date:

Table 2 The records of sampling and test items for environmental parameters tests（G8）

TEST CYCLE: _____

Lot No.	Sampling time	Sampling volume	Sampling point

Parameters including: pH, Temperature, Salinity, DO, TSS, DOC, POC, NTU

Recorder:

Date:

Supervisor:

Date:

Table 3 The records of sampling for different size plankton tests （G8）

TEST CYCLE: _____

Lot No.	Sampling time	Sampling volume （L）	Sampling point	Test items

Recorder:

Date:

Supervisor:

Date:

Table 4 The records of sampling for bacteria tests （G8）

TEST CYCLE: _____

Lot No.	Sampling time	Sampling volume (L)	Sampling point	Test items

Recorder:

Date:

Supervisor:

Date:

Table 5 The records of decay of TRO concentration in treated tank （G8）

(on-line TRO analyzer)

Time，h	0h	24h	48h	72h	96h	120h	Test cycle and time of treatment
TRO concentration，mg/L							

Recorder:

Date：

Supervisor:

Date：

Table 6 The records of sampling for aquatic toxicity tests（G9）

TEST CYCLE：_____

Lot No.	Samples description	Sampling point	Required sampling volume, barrels（230kg/barrel）	Actual sampling volume, barrels（230kg/barrel）	Sampling time

Test items:

.1 growth inhibition test to marine algae;
.2 acute toxicity tests to marine fish;
.3 chronic toxicity tests tomarine fish;
.4 acute toxicity tests to marine invertebrate;
.5 chronic toxicity tests to marine invertebrate.

Recorder: Supervisor:

Date： Date：

Table 7 The records of sampling for chemical analysis（G9）

TEST CYCLE：_____

Lot No.	Samples description	Sampling point	sampling volume, L	Sampling time

Recorder:

Date：

Supervisor:

Date：

Table 8 The records of sampling for physical and chemical properties tests (G9)

TEST CYCLE: _____

Lot No. (triplicate)	Sample description	Sampling point	Sampling volume, L (each parallel sample)	Sampling time

Physical and chemical properties including: pH, temperature, salinity, DO, TSS, DOC, POC, NTU, relative density, Oxidation/reduction potential

Recorder:

Date:

Supervisor:

Date:

Table 9 The records of hydrogen gas measurement (G9)

TEST CYCLE: _____

Hydrogen gas measurements in the surrounding of the BalClor™ BWMS

Test time	Concentration of hydrogen gas in the surrounding of BWMS, v/v %
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	
24h after the end of electrolysis	

Recorder: Supervisor:

Date: Date:

Hydrogen gas measurements in the headspace of treated tank

Test time	Concentration of hydrogen gas in the headspace of treated tank, v/v %
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	
12h after the end of electrolysis	
24h after the end of electrolysis	
48h after the end of electrolysis	
72h after the end of electrolysis	
96h after the end of electrolysis	
120h after the end of electrolysis	

Recorder:

Date:

Supervisor:

Date:

Hydrogen gas measurements upon discharge of vent pipe of degas tank

Test time	Concentration of hydrogen gas upon discharge of vent pipe of degas tank, v/v %
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	

Recorder:

Date:

Supervisor:

Date:

Table 10 The records of Sampling for chlorine gas measurement (G9)

TEST CYCLE: _____

Chlorine gas measurements in the surrounding of the BalClor™ BWMS

Plan sampling time	Sampling time
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	
24h after the end of electrolysis	

Chlorine gas measurements in the headspace of treated tank

Planned sampling time	Sampling time
Before electrolysis	
0.5h after the beginning of electrolysis	
1h after the beginning of electrolysis	
2h after the end of electrolysis	
3h after the end of electrolysis	
6h after the end of electrolysis	
12h after the end of electrolysis	
24h after the end of electrolysis	
48h after the end of electrolysis	
72h after the end of electrolysis	
96h after the end of electrolysis	
120h after the end of electrolysis	

Recorder: Supervisor:

Date: Date:

Table 11 The records of concentration of TRO in the treated tank and control tank （Lab test）

TEST CYCLE: _____

Time		0h	12h	24h	48h	72h	96h	120h
Concentration of TRO in treated tank	Sampling time							
	Sampling volume (L)							
Concentration of TRO in control tank	Sampling time							
	Sampling volume (L)							

Recorder:

Date:

Supervisor:

Date: